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FEASIBILITY OF THE NATO ACCS SENSOR FUSION POST (SFP)

R. A. Enlow, *Project Leader*

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This IDA Document provides a realisitc, acquisition-based assessment of the feasibility of producing and fielding an Air Command and Control System (ACCS) Sensor Fusion Post (SFP) by 1998. Existing systems were surveyed, their technical compliance with ACCS functional requirements was estimated, and the state of development documented. No appropriate system was identified. The study concluded that no complete sensor fusion capability could be fielded by 1998 and alternatives were suggested.

14. SUBJECT TERMS : Air Command and Control System, ACCS, Sensor Fusion Post, SFP, Automated Precision IFF Surveillance System, APIS, Cooperative Engagement Capability, CEC, Multispectral Multisensor Fusion Processor,MMFP, Dornier Deutsche Aerospace Multisensor Tracker, DDAMST

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INSTITUTE FOR DEFENSE ANALYSES

Contract MDA 903 89 C 0003
Task T-J1-684

PREFACE

This study was conducted by the System Evaluation Division of the Institute for Defense Analyses (IDA) in response to a request by the Office of the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence [OASD (C3I)][1]

The IDA study team, made up of Dr. Ronald A. Enlow (Project Leader) and Col. Louis L. Simpleman (USMC, Ret.), gratefully acknowledges the review comments of the IDA Technical Review Committee. The committee was chaired by Dr. David L. Randall, Director, System Evaluation Division, and members were Dr. John R. Shea, Dr. Peter S. Liou, Mr. Harold A. Cheilek, and Dr. Herbert M. Federhen.

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1 *Options to Improve the European Theater Air Command and Control System*, Contract MDA 903-89-C-003, Task T-J1-684, Amendment 3, November 1990, UNCLASSIFIED.

BRIEFING OUTLINE

- TASKING
- BACKGROUND
- APPROACH
- FEASIBILITY CRITERIA
- SITE SURVEY
- EVALUATION OF CANDIDATE SYSTEMS
- CONCLUSIONS
- RECOMMENDATIONS

This briefing has been prepared as part of Task T-J1-684, Options to Improve the European Theater Air Command and Control System (ETACCS) undertaken during Fiscal Year 1990. Subtask 6 directs the study team to perform an assessment of the technologies required to support the Air Command and Control System (ACCS) sensor fusion post (SFP) concept and to determine the feasibility of implementing the SFP concept during the late 1990s.

Previous ETACCS tasks have identified the SFP as the only proposed ACCS entity whose acquisition entails considerable technological risk. At the present time there is no operational sensor fusion capability within the NATO nations. In addition to technological risk, NATO operational requirements are being redefined in order to reflect the changing reality of the Soviet threat. It is clear that the planned ACCS acquisition program will face reduced funding profiles as a consequence of the redefinition. It is very important that the ACCS community avoid programming funds for entity types whose implementation may not be feasible. This briefing summarizes the feasibility assessment conducted by the ETACCS project team.

TASKING

- TASK T-J1-684 (ETACCS) SUBTASK 6 DIRECTS THE STUDY TEAM TO:
  - Perform an assessment of the technologies required for the ACCS sensor fusion post (SFP) concept
  - Determine the feasibility of implementing the SFP concept during the late 1990s

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An understanding of the ACCS sensor fusion post concept is essential to meet the goals of the task.

As a key entity in the ACCS surveillance concept, the SFP receives plot data (azimuth, range, elevation) from up to 24 active and passive sensors and fuses the data to establish and maintain tracks of air targets in its surveillance coverage area. The SFP first produces the local air picture (a combination of air tracks and associated identification information), and then provides the local air picture to the Recognized Air Picture (RAP) Production Centre (RPC). Generally, two SFPs are planned to be subordinate to a single RPC.

The sensor fusion process is made complex by the following:

- The number of subordinate reporting posts (maximum 24/SFP)
- The number of targets that the SFP must track (250-500 targets)
- The need to accommodate both active and passive sensors
- The multi-plot variable update (MPVU) fusion approach specified in the ACCS Master Plan (See definition on page 10).

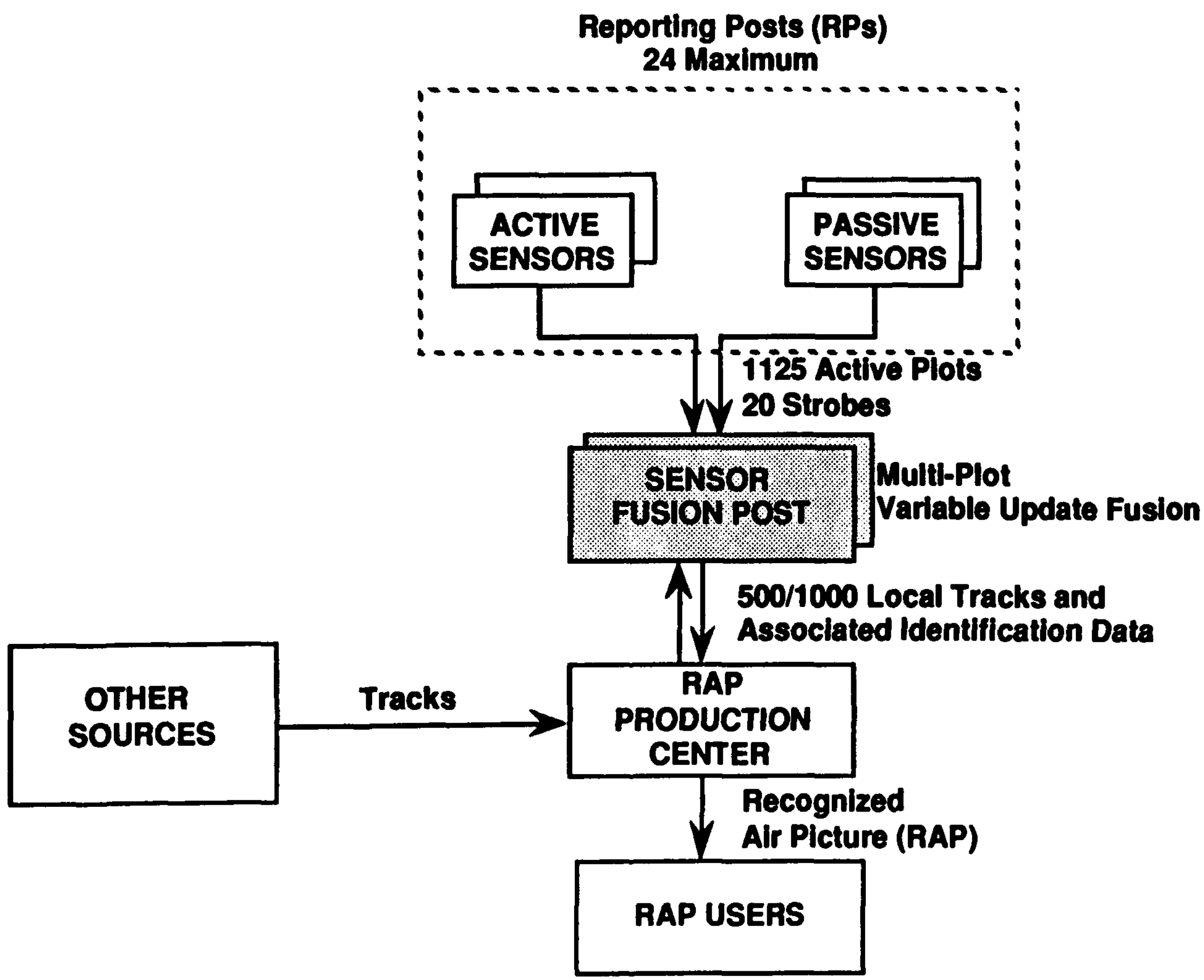
The number of subordinate of reporting posts, each reporting a great many targets, requires that the SFP rapidly process a massive amount of plot data. Because passive sensors generate relatively inaccurate information, they require algorithms that use a heuristic or decision tree approach, which requires processing time that increases exponentially as the number of passive sensors is increased.

The availability of a multi-plot variable update (MPVU) track fusion concept is a key technological driver in implementing the SFP concept. Attempts to fuse sensor data in the past have been hampered by limited processing power and the inability to develop the algorithms that meet the minimum fusion requirements.

The requirement to update a large number of tracks at a variable rate is the most difficult of the sensor fusion algorithm requirements. However, if successful, it can produce the best operational results.

BACKGROUND

ACCS SURVEILLANCE SYSTEM CONCEPT



The SFP will provide significant operational improvements over the present systems through its ability to extract target data in clutter, to track maneuvering targets and to improve the RAP update rate to 5 seconds, as opposed to the nominal 10-second rate of today's systems. Further, the SFP will allow real-time sensor management of radars and passive sensors. This improves overall system availability and survivability.

The SFP establishes a local air picture by fusing various sensor inputs. The SFP is comprised of the following functional modules: S-02 (Surveillance-02) Sensor Data Fusion and C2RM-05 (Command, and Control Resource Management-05).[2]

Functional module S-02 consists of the following key tasks:[3]

4.2.1 Pre-process Sensor Data

4.2.2 Fuse Pre-processed Data (Plot/Strobe to Track)

4.2.4 Triangulate Sensor Data

4.4.1 Perform ID Sensors and Sources Combining Process

4.4.2 Resolve Conflicts

4.2.5 Hand Over Sensor Data

4.4.5 Update Track Data

4.3.1 Display Track Data

4.3.2 Display Local Plot Data

4.3.3 Display ID Data

4.7.1 Establish Surveillance Guidance for RP

4.8.1 Simulate Air Situation and ECM Environment

4.9.1 Record Track Data

Key tasks 4.2.1, 4.2.2, 4.2.4, 4.4.1 comprise the criteria used in this study to establish the feasibility of the ACCS SFP.

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2 Volume IV, Overall ACCS Design, Supporting Document 4, Structure and Characteristics of Organizational Components, Annex D, page 129 ACCST (86) 3321057/SD4 (Revised), June 1988.

3 Ibid, Annex C, page 118.

BACKGROUND

ACCS SURVEILLANCE SYSTEM CONCEPT (CONT'D)

	FUNCTION	PRODUCT
SENSORS	Detect Acquire Cooperative ID Data Acquire Non-Cooperative ID Data	Position Plots/Strobes Associated ID Data Colored Strobes
SFP	*Multi Plot Variable Update Fusion* Associate ID Processing Generate Local Air Picture	Tracks ID Associated With Track Local Air Picture
RPC	Track-to-Track Correlation ID Declaration Produce Recognized Air Picture	Correlated Tracks Identified Tracks Recognized Air Picture

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The existing NATO surveillance systems use track data from radars, which are subordinate to reporting posts (RPs) that generally are remotely located. Radars report tracks to the RPs, which then send track and identification information to a command and control agency.

The C2 facility may receive tracks from multiple RPs via LINK 1 at an update rate of 10 sec for every RP. The C2 entity then selects the track for display by using the track with the best track quality, in some cases, or by using a tracking scheme based on correlation for other systems.

The current C2 entities essentially use information from one source at a time and disregard all other data to build a local air picture and to identify tracks. This identified track is then shared with other C2 entities.

The ACCS SFP is quite different in concept and presents extremely difficult technological problems. The SFP consequently presents the highest development risk when compared to other ACCS entities. No operational system has been identified that does plot-to-plot fusion in a target-rich environment using data from a large number of active and passive sensors.

ACCS SURVEILLANCE CONCEPT (CONT'D)

- THE ACCS SENSOR FUSION POST PRESENTS THE MOST DEVELOPMENT RISK
  - No analog of an SFP exists
- THE KEY TO ACCS SENSOR FUSION POST IS THE MULTI-PLOT VARIABLE UPDATE FUSION PROCESS
  - No operational system has accomplished multi-plot variable update (MPVU) fusion for the required number of targets
  - Expands processing requirements
  - Must accommodate hundreds of aircraft

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The proposed MPVU fusion process combines plot information from multiple active and passive sensors to establish and maintain tracks. The tracks are updated at variable intervals, based upon the arrival of each new plot at the SFP. The variable update rate is faster than conventional multi-radar trackers and allows tracking of low flying, high speed, maneuvering targets. The requirement is consistent with the pre-CFE threat.

It should be noted that the ACCS master plan proposed the acquisition of large numbers of active and passive sensors. Clearly, the acquisition of such a sensor suite is no longer financially feasible. The post-CFE threat is under review by NATO military authorities. It also seems likely, that the operational need for large numbers of fixed sensors can no longer be justified. Under these circumstances, the perceived benefits of MPVU cannot be realized.

BACKGROUND

MULTI-PLOT VARIABLE UPDATE (MPVU) FUSION

- USES TARGET POSITION INFORMATION FROM MULTIPLE ACTIVE/PASSIVE SENSORS
- COMBINES PLOT DATA FROM THE SENSORS
- PRODUCES TRACK UPDATES AT VARIABLE INTERVALS BASED UPON THE ARRIVAL OF EACH NEW PLOT AT THE SFP
- PROVIDES FASTER DATA UPDATE RATE THAN CONVENTIONAL MULTI-RADAR TRACKERS

The RAP update rate is a SHAPE operational requirement and is defined in the ACCS Master Plan to be 5 seconds. Given this requirement, the ACCS study team established an estimated timing budget for generating the RAP. The times allocated for the various activities are estimates based on their experience and the current state of the art. The 0.5 second allowed for the fusion process compares reasonably with the time used by current systems, although they do not use the MPVU concept.

BACKGROUND

TIMING REQUIREMENTS

- THE ACCS MASTER PLAN REQUIRES RAP UPDATE RATE OF 5 SEC
- ESTIMATED TRACK TIMING BUDGET ALLOWS SFP 0.5 SEC PROCESSING TIME
- WITHIN THIS 0.5 SEC THE SFP MUST PROCESS THE PLOT OUTPUT OF UP TO A MAXIMUM OF 24 ATTACHED RADARS (ACTIVE AND PASSIVE)

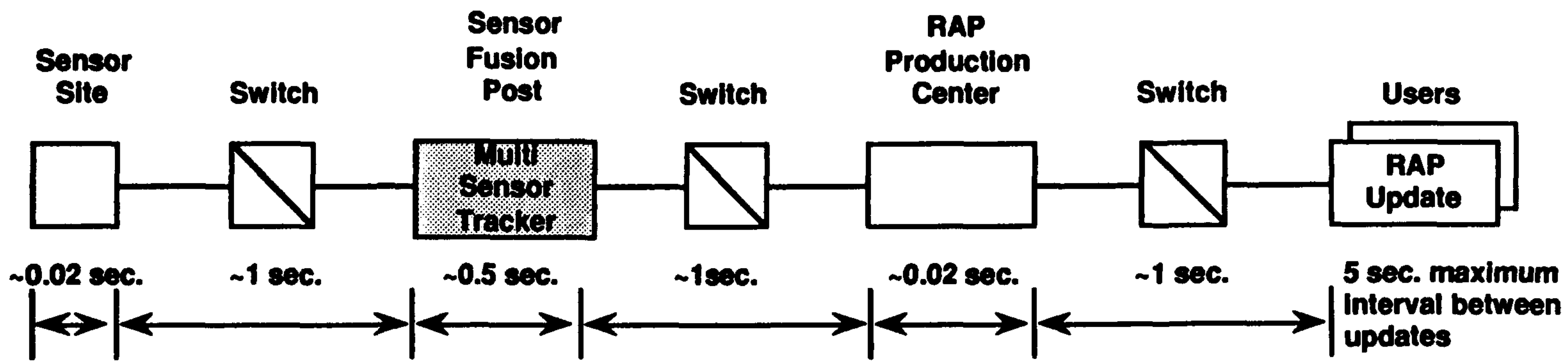
The stringent timing requirements are a result of a user need for a 5-second update rate for the RAP. The times shown for the various phases are ACCS team estimates based on experience, demonstrated and projected technological capability.

The IDA study team had some difficulty accepting 1-second switching and transmission delays; however, their acceptance does lead to a conservative SFP time budget. It should also be noted that there are an additional 1.46 seconds of unallocated time.

Note: Since switching and transmission times are included in the timing budget, the update rate is, strictly speaking, a latency requirement. It represents the total time delay of track data from sensor to user.

BACKGROUND

ACCS MASTER PLAN ESTIMATED TRACK TIMING BUDGET



- Determine Position (Plots/Strobe)
- Assign ID

- Fuse Plots into Tracks
- Process Associated IDs
- Generate Local Air Picture

- Correlate Track-to-Track
- Produce Recognized Air Picture

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The approach used by the IDA study team for determining the feasibility of delivering an SFP by the late 1990s was to:

- Define the feasibility criteria using the real-world constraints imposed by schedule and technological maturity.
- Survey existing systems, prototypes, and models to determine the state and extent of current sensor fusion technology.
- Finally, after selecting the systems that have demonstrated a potential for satisfying the SFP requirements, apply the criteria to those systems.

APPROACH

- DEFINE FEASIBILITY CRITERIA FOR A LATE 1990s SENSOR FUSION POST IMPLEMENTATION
- SURVEY EXISTING TECHNOLOGY AND VISIT OPERATIONAL SYSTEMS THAT HAVE DEMONSTRATED FUSION CAPABILITY
- APPLY CRITERIA TO THESE SYSTEMS

A straightforward approach examines the requirements and applies the real-world constraints to define the criteria for a late 1990s sensor fusion implementation.

In order to meet a delivery in 1998, the technology directly applicable to SFP development must be relatively mature. The critical technical areas must have been demonstrated to provide confidence in their operational feasibility.

The stringent requirement to fuse data from many active and passive sensors is the most difficult technical challenge. In order to succeed, the SFP must have developed algorithms to provide the required tracking and identified the computer with the speed and architecture with which to do it.

FEASIBILITY CRITERIA

- FOR A LATE 1990s DELIVERY, A PROTOTYPE SFP MUST HAVE ALREADY DEMONSTRATED THE FOLLOWING:
  - THE ABILITY TO FUSE HUNDREDS OF ACTIVE AND PASSIVE SENSOR PLOT DATA FROM MULTIPLE SOURCES
  - THE ALGORITHMS AND COMPUTER POWER TO PROCESS DATA IN THE BUDGETED TIME

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Schedule is a driving criterion for the feasibility of delivering a sensor fusion post in the 1998-2000 time period.

A typical U.S. program schedule that is common to all procurement includes the following:

- Four to five years of research and development are necessary to demonstrate and validate a concept.
- Five to six years of additional effort are necessary to build an engineering model that is as near to the production item as possible and capable of being "mass" produced.
- Testing is required during each phase to identify and reduce the risks associated with the next phase.

FEASIBILITY CRITERIA (CONT'D)

- THIS STUDY ASSUMED THAT CERTAIN PROCESSES MUST BE FOLLOWED WHETHER A U.S. OR A NATO PROCUREMENT IS UNDERTAKEN

- A TYPICAL U.S. PROGRAM SCHEDULE INCLUDES THE FOLLOWING PHASES:

  - Demonstration and validation
  - Engineering and manufacturing
  - Production
  - Testing during each phase

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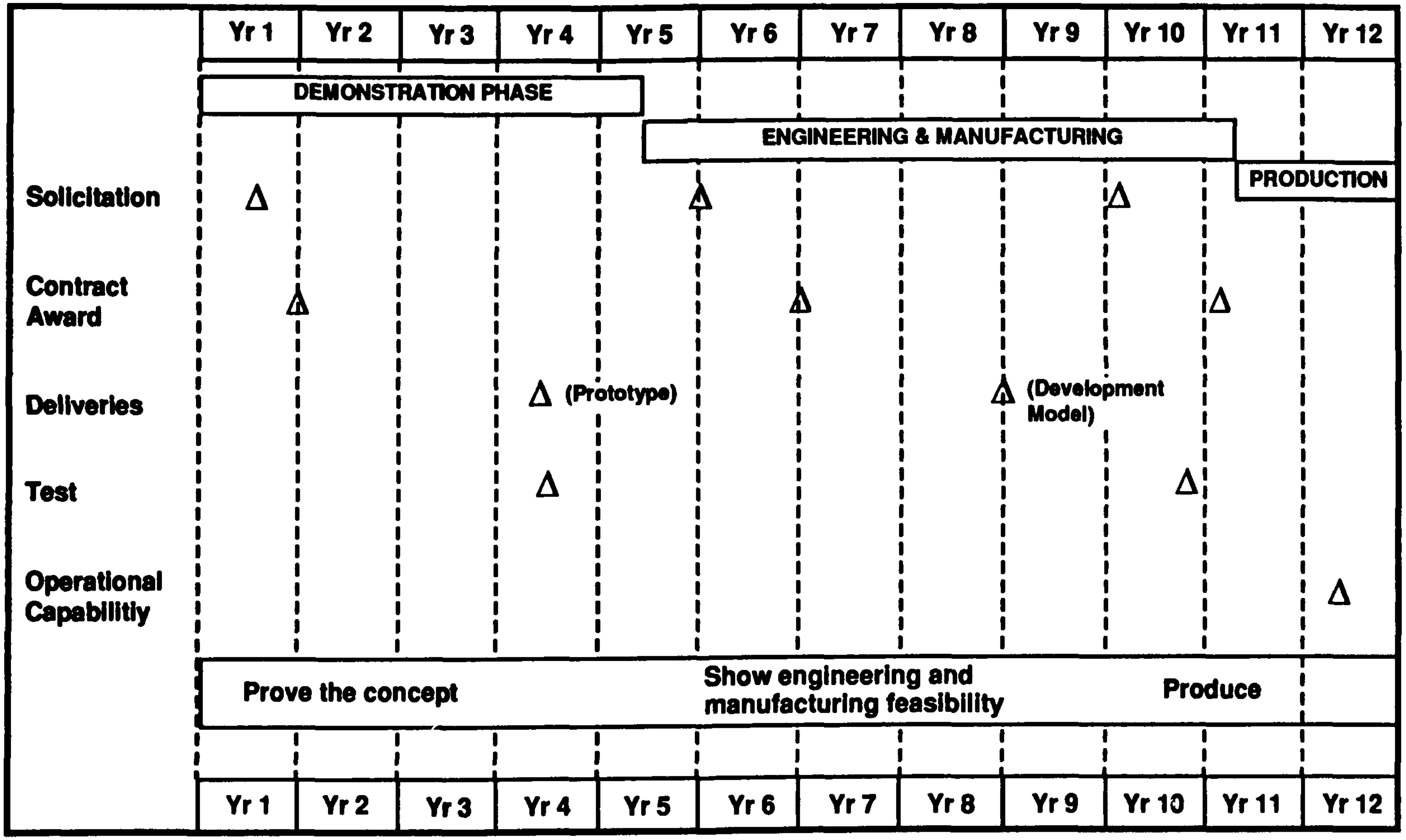
A typical U.S. acquisition requires time and resources. It includes the administrative time to solicit, receive, and evaluate the proposals and to award the contracts. A conservative estimate of time required to progress through all the phases is 12 years. This schedule assumes that no technical difficulties are encountered.

FEASIBILITY CRITERIA (CONT'D)

TYPICAL ACQUISITION SCHEDULE



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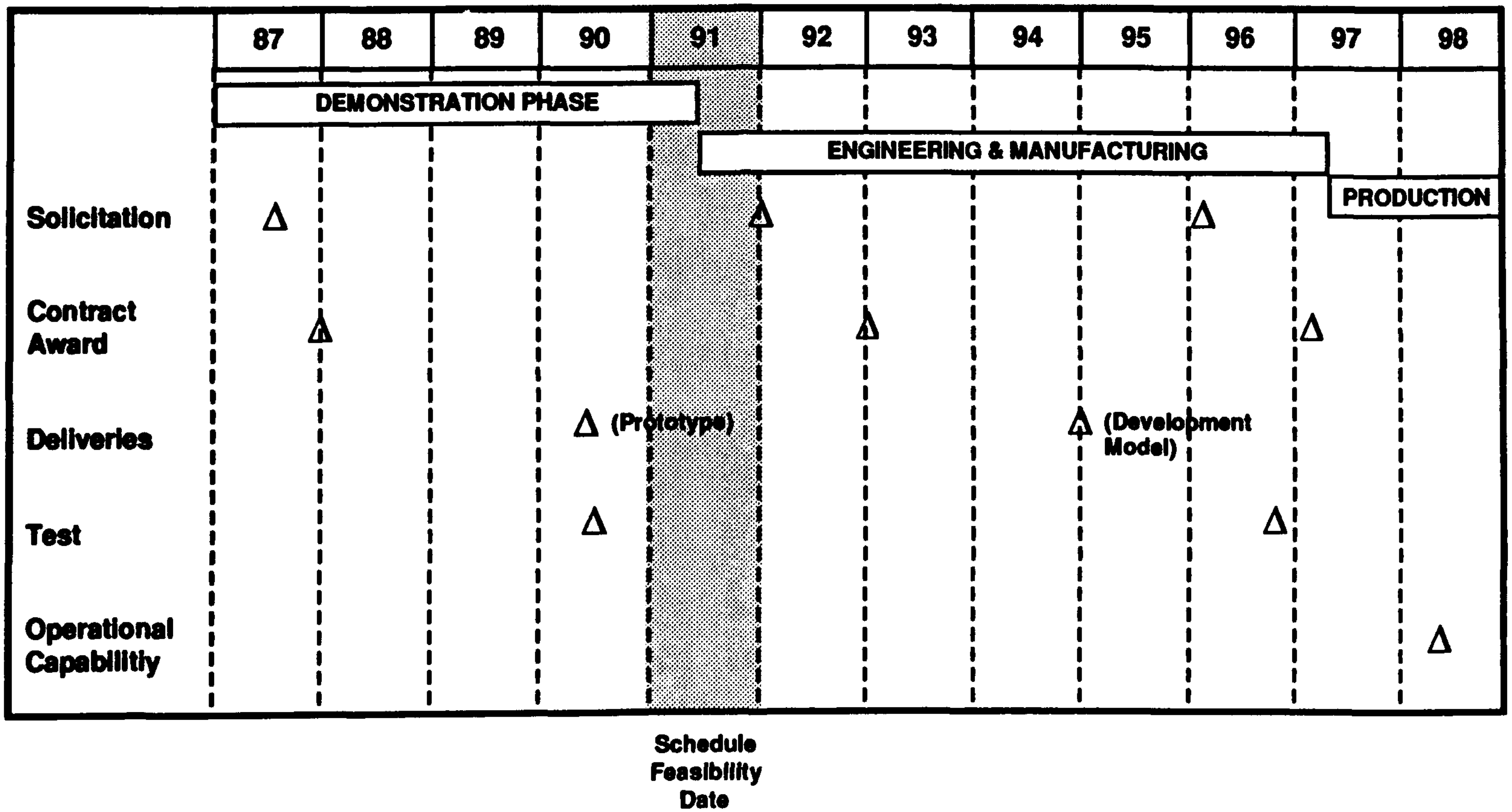
A laydown of a schedule that would provide an SFP by 1998 clearly shows that, in order to meet the 1998 delivery, a program must be in the early engineering and manufacturing phase in 1991. By this time, the technical feasibility must have been demonstrated through realistic tests. This laydown also implies that the demonstration phase should have begun in 1987 (which it did not).

FEASIBILITY CRITERIA (CONT'D)

SFP FEASIBILITY SCHEDULE



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The feasibility criteria applied to the systems surveyed were technical and schedule. The two criteria are inter-dependent. Obviously, the technically mature system presents a lower risk than a less mature system and the probability of meeting the desired schedule is higher.

FEASIBILITY CRITERIA (CONT'D)

FOR A LATE 1990s DELIVERY:

- THE SENSOR FUSION POST DEVELOPMENT MUST BE IN AN ADVANCED DEMONSTRATION AND VALIDATION PHASE (OR FURTHER ADVANCED) AT THIS TIME
  - A brassboard or advanced development model must exist and the technical feasibility demonstrated
  - Formal testing is planned in the near future
  - The non-operational issues - supportability, training, H/W and S/W architecture - have been identified and resolved

The initial step in the survey was a documentation search to identify potential systems for further investigation. Sensor fusion experts from the government and industry were interviewed to provide other areas of possible interests. Finally, for the promising systems, there were visits to the sites that indicated a fusion capability.

SITE SURVEY

- AN INITIAL SURVEY IDENTIFIED CANDIDATE SYSTEMS
- THE SURVEY INCLUDED:
  - Visits to operational and R&D sites
  - Discussions with sensor fusion experts
  - Review of the literature
- SITE VISITS:
  - Automated Precision IFF Surveillance (APIS)
    Barking Sands, Kauai, HI
    Point Mugu, Oxnard, CA
  - Multi-Spectral, Multi-Sensor Fusion Processor (MMFT)
    Rome Air Development Center, Rome, NY

Visits included on-site surveys at government and contractor facilities. The visits consisted of discussions with technical experts on the various systems capability and a review of tests/demonstrations results, when appropriate.

SITE SURVEY (CONT'D)

- R&D CENTERS
  - Applied Physics Laboratory
    Laurel, MD
  - Alpha Tech, Inc.
    Burlington, MA
  - Litton Data Systems
    Van Nuys, CA
  - Hughes Ground Systems Div.
    Fullerton, CA
  - Thomson-CSF, Inc.
    Palo Alto, CA

The survey identified four systems that have demonstrated a capability of fusing data from multiple sensors. These systems were selected because they used plot-to-plot or plot-to-track fusion algorithm, and discussions with the project leaders indicated that a model exists and performance data are available. Discussions with experts on the systems and literature provided the basis for the analysis.

SITE SURVEY (CONT'D)

- FOUR CANDIDATE SYSTEMS DEMONSTRATED SOME POTENTIAL TO MEET THE SENSOR FUSION REQUIREMENT
  - Automated Precision IFF Surveillance System (APIS)
  - Cooperative Engagement Capability (CEC)
  - Multispectral Multisensor Fusion Processor (MMFP)
  - Dornier Deutsche Aerospace Multi Sensor Tracker (DDA MST)
- NO OTHER SYSTEMS ARE KNOWN TO EXIST AS SFP CANDIDATES

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The APIS provides automated tracking of air, surface, and subsurface targets at U.S. Navy test ranges at Barking Sands, Kauai, HI and Point Mugu, CA.

APIS uses a plot-to-track fusion algorithm for relatively low speed (130 Kts) air targets. it integrates information from up to 18 active radars but does not use passive sensor data. APIS has the theoretical capability of tracking 2,000 targets and has demonstrated the ability to track 300 targets.

The Navy uses APIS to detect targets within test range boundaries during ordnance testing. It has been in operation since 1989 and performs well. The study team concluded that the inability to fuse active and passive sensor plot data is a major drawback that must be overcome and demonstrated prior to any conclusion that APIS is capable of meeting the ACCS requirements for an SFP. Further tests must include high speed maneuvering targets to determine if the APIS can be extrapolated to fast maneuvering airborne targets. The plot-to-track algorithm precludes the update rate provided by an MPVU approach.

CANDIDATE SYSTEMS

AUTOMATED PRECISION IFF SURVEILLANCE SYSTEMS (APIS)

PURPOSE: TO PROVIDE AUTOMATED PRECISION TRACKING OF AIR, SURFACE, AND SUBSURFACE TARGETS AT USN TEST RANGES

CAPABILITY:

- PLOT-TO-TRACK INITIATION AND MAINTENANCE ON LOW SPEED TARGETS (<130 ETS)
- 500+ TARGET CAPACITY (THEORETICAL)
- UP TO 18 RADARS, NO PASSIVE SENSORS USED

STATUS:

- OPERATIONAL SYSTEMS AT PT MUGU, CA AND BARKING SANDS, HAWAII
- DEMONSTRATED 300 TRACK CAPACITY

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The Cooperative Engagement Capability (CEC) is a U.S. Navy development that fuses plot data from up to 10 surveillance radars from multiple ships. Its purpose is to provide a common air picture to up to forty ships with information of sufficient quality to allow detection of aircraft and anti-ship missiles before they break the horizon.

The CEC uses an advanced architecture and has a robust (10MB bandwidth) communication system to transfer plot data from the radars to the signal processor. It does not process information from passive sensors. It uses a multi-plot variable update (MPVU) algorithm that results in a capability to update tracks frequently (faster than 10 sec).

The system exists as an advanced development model and has shown the capability to fuse data from multiple sources. Since a passive sensor capability has not been demonstrated, the test results reflect only a portion (active sensor) of the full ACC sensor fusion post requirement and therefore the risk of meeting a 1998 delivery of a fully compliant ACCS SFP is high.

RESULTS (CONT'D)
CANDIDATE SYSTEMS

COOPERATIVE ENGAGEMENT CAPABILITY (CEC)

PURPOSE: TO INTEGRATE PLOT DATA FROM MULTIPLE (UP TO 10) SHIPBOARD SURVEILLANCE RADARS (USN)

CAPABILITY:
- PLOT-TO-PLOT INTEGRATION
- 500+ TARGET CAPACITY (THEORETICAL)
- NO PASSIVE SENSORS
- REQUIRES 10MB BANDWIDTH SUPPORTING COMMUNICATIONS SYSTEMS

STATUS:
- ADVANCED DEVELOPMENT MODEL TESTED IN 1990
- FUNDING FOR CONTINUED DEVELOPMENT IS PROGRAMMED

LL/vrm(04/15/91)-22BU

The Multi-Spectral Multi-Sensor Fusion Processor (MMFP) is a real-time sensor fusion testbed that blends information from multiple active and passive radars. Its primary function is to evaluate observable airborne tracking applications under "noisy" sensor stressing conditions. It is a plot-to-track initiation and maintenance approach using data from multiple active and passive radars. Detection reports are time-tagged, reformatted, grouped, and held in the processor until a full-scan cycle of data is received. In this sense, the MMFP is a multi-plot averaging (MPA) approach rather than an MPVU algorithm.

The MMFP has demonstrated the capability to track multiple aircraft (70) while they maneuvered. Since the number of aircraft tracked thus far is relatively small when compared to the ACCS requirement, and since the MMFP uses the MPA rather an MPVU approach, the study team felt that the testbed corresponds to a brassboard model. The number of aircraft and the use of an MPVU algorithim severely impact the processing requirements of the processor. Further development of the tracking algorithm to demonstrate the MPVU capability and an increased number of tracks must be tested. Each of these requires additional processing time above what has been shown thus far in tests of the MMFP.

The MMFP does use an approach that could possibly serve as a basis for a future system, but most likely it could not be delivered by 1998.

RESULTS (CONT'D)
CANDIDATE SYSTEMS

MULTI-SPECTRAL MULTI-SENSOR FUSION PROCESSOR (MMFP)

PURPOSE: TO PROVIDE A TOOL/TESTBED FOR EVALUATION OF SENSOR FUSION CONCEPTS/ALGORITHMS (USAF)

CAPABILITY:

- PLOT-TO-TRACK INITIATION AND MAINTENANCE
- FUSED RADAR AND PASSIVE SENSOR DATA
- 500+ TRACK CAPACITY (THEORETICAL)

STATUS:

- BRASSBOARD MODEL
- DEMONSTRATED 70 TRACK CAPACITY

LL/vrm(04/15/91)-23BU

The Dornier Deutshe Aerospace Multi-Sensor Tracker (MST) is a prototype built by this German company to demonstrate the advantages of active and passive sensor tracking. The MST uses a plot-to-plot algorithm only for active radars and uses passive sensors to supplement the identification process. The passive sensor information assists in maintaining tracks in a high clutter environment.

The Dornier Deutshe Aerospace system is, in essence, a technology demonstration. The data available showed the results of tracking two aircraft during maneuvers in a high clutter environment. The results show that fusing active and passive sensor data is feasible.

The fact that it is a technology demonstration using two aircraft shows an immature system that is in the early phase of development. Significant development and testing remains to prove the viability of applying this technique to ACCS. The likelihood of fielding an SFP with this approach by 1998 is remote.

RESULTS (CONT'D)
CANDIDATE SYSTEMS

DORNIER DEUTSCHE AEROSPACE MULTI-SENSOR TRACKER (DDA MST)

PURPOSE: TO DEMONSTRATE ADVANTAGES OF ACTIVE AND PASSIVE SENSOR TRACKING

CAPABILITY:

- PLOT-TO-TRACK FOR ACTIVE RADARS ONLY
- USE OF PASSIVE SENSORS TO SUPPLEMENT ID AND TRACKING IN HIGH CLUTTER AND MANEUVERING TARGET ENVIRONMENT
- TRACK CAPACITY UNKNOWN

STATUS:

- PROTOTYPE DEMONSTRATED FOR FEW TARGETS

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The summary shows the evaluation of the systems when compared to the feasibility criteria. Only two of the systems, the MMFP and the MST, fuse data from both active and passive sensors, whereas the other two systems, the APIS and CEC, do not fuse data from passive sensors. The lack of a demonstrated capability to process hundreds of targets, using information from active and passive sensors, argues to a low technical level for all of the systems.

Note: The technical criteria abbreviated "MPVU" consists of Key Tasks 4.2.1, 4.2.2, 4.2.4 and 4.4.1 of the S-02 Functional Module (page 6).

EVALUATION OF CANDIDATE SYSTEMS

System	Technical Characteristics			Schedule Status	Candidate System Evaluation	
	Theoretical Tracking Capacity/ Demonstrated Capacity	Accomodates Active Sensors	Accomodates Passive Sensors	Acquistion Phase	Schedule Criteria	Technical Criteria
ACCS Requirements	500/none	Yes	Yes	Requirements Identified	Capability by 1998	MPVU
Automated Precision IFF Surveillance System	500+/300	Yes	No	Test Facility Operational	Yes	No
Cooperative Engagement Capability	500+/Variable	Yes	No	Advanced Development Model	Yes	No
Multi-Spectral Multi-Sensor Fusion Processor	500+/70	Yes	Yes	Brassboard Model	Yes	No
Multi-Sensor Tracker	TBD/2	Yes	Yes	Brassboard Model	Yes	No

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The technical evaluation reports on the four systems already identified in the survey at the brassboard stage or beyond. Consequently, the study concluded that they all can likely meet the schedule criteria. However, none of the systems met the technical criterion and it is unlikely that a SFP can be developed, tested, and delivered by the late 1990s. The risk associated with bringing the prototype/brassboard models to operational capability is high and cannot be done in a short period of time.

No known system can be produced, tested, and delivered by 1998 with certainty, therefore, the usefullness of the distinct functional entity, i.e. the SFP, would now appear to be limited. Furthermore, the various references to the SFP as a distinct physical entity would also appear less than useful.

CONCLUSIONS

- NONE OF THE SYSTEMS IDENTIFIED IN THE SURVEY MEET BOTH SCHEDULE AND TECHNICAL CRITERIA
  - The functional module S-02, sensor data fusion cannot entirely be accomplished by 1998
- CONSEQUENTLY IT IS UNLIKELY THAT A PHYSICAL SENSOR FUSION POST CAN BE DEVELOPED, TESTED, AND PRODUCED BY THE LATE 1990s
- THE USEFULNESS OF THE SENSOR FUSION POST AS A DISTINCT FUNCTIONAL OR PHYSICAL ENTITY IS LIMITED

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The low probability of delivering a functionally complete SFP by 1998 dictates that the NATO ACCS community rethink current fielding plans. Further, the extensive suite of sensors originally forseen, will not be realized. Under these circumstances the operational advantages offered by a fully capable SFP will cannot accrue.

Consequently, the MPVU concept should be dropped and the key tasks which remain technically feasible in S-02 should be merged into the RAP Production Center functions as appropriate.

Based on the above, the term "Sensor Fusion Post" should be dropped. No further reference should be allowed to either the functional or physical concept.

The ACCS community should reexamine the suitability of existing multi-radar trackers for inclusion of the most operationally effective process at the RPC.

The ACCS community should reexamine the implications of removing the physical SFP on sensor-to-RPC communications.

RECOMMENDATIONS

- THE NATO ACCS COMMUNITY SHOULD CONSIDER THE FOLLOWING COURSES OF ACTION
  - The MPVU concept should be dropped
  - The key tasks which remain technically feasible in S-02 should be merged into RPC functions
  - The term Sensor Fusion Post should be dropped
  - The suitability of existing multi-radar trackers should be examined
  - The requirements for sensor to RPC communications should be examined.

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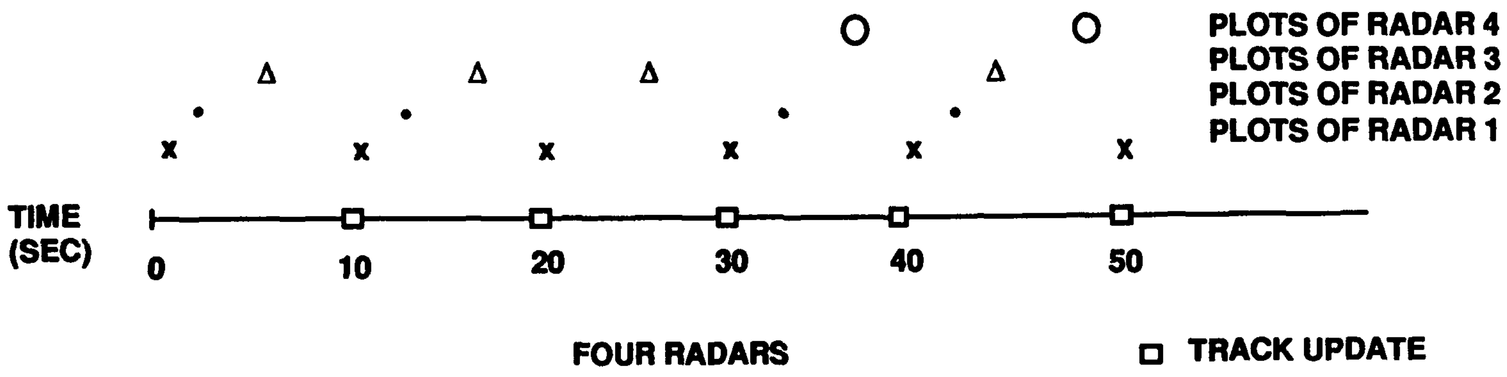
ANNEX A

A graphic comparison of track data for a constant-interval Multi-Radar Tracker (MRT) and the Multi-Plot Variable Update (MPVU) illustrates the advantages of the MPVU concept. For the constant-interval tracker, information is collected over the scan time of a radar. The information is processed and updated at the scan rate. For a radar with a scan period of 10 seconds, the tracker will update the tracks five times in the 50-second period shown in the example.

BACKGROUND
CONSTANT-INTERVAL MULTI-RADAR TRACKER



ASSUMES ALL RADARS SCAN AT A 10 SECOND RATE, ASYNCHRONOUSLY

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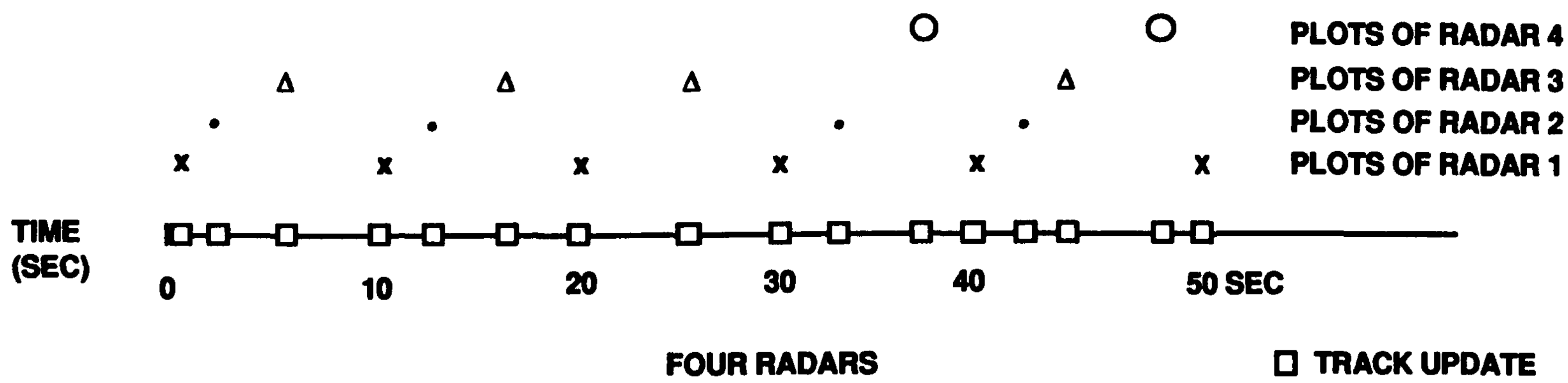
The MPVU tracker theoretically updates the track after receipt of each associated plot from every radar. For the four radar examples shown, there are approximately three times the number of updates for the MPVU tracker than for the constant-interval MRT.

The increase in data increases the probability of detection of targets in a high clutter environment and improves the tracking capability of fast, maneuvering targets. Obviously, the processing time required for the MPVU tracker is significantly greater than for the constant-interval MRT.

Note that for this example, there are three times as many track updates in the 50 sec interval than for the case of the constant interval MRT example.

BACKGROUND
MPVU TRACK UPDATE



ASSUMES ALL RADARS SCAN AT A 10 SECOND RATE, ASYNCHRONOUSLY

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SCHEDULE

- DURING THE DEMONSTRATION AND VALIDATION PHASE: (2-4 YEARS)
  - Objectives are:
    - Define the critical design characteristics
    - Demonstrate the ability to incorporate critical technologies
    - Prove understanding of processes essential to important system concepts
    - Identify cost considerations
  - Approach is:
    - Build prototypes to prove concept, i.e., brassboards, advanced development models, laboratory models, etc.
    - Test and conduct an early operational assessment
  - Other factors considered are:
    - Logistics, personnel and training requirements
    - Affordability
    - Acquisition strategy

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SCHEDULE (CONT'D)

- **DURING THE ENGINEERING AND MANUFACTURING PHASES: (5-6 YEARS)**
  - **Objectives are:**
    - **Translate preferred design approach into stable, producible and cost effective design**
    - **Validate the manufacturing process**
    - **Define cost considerations**
  - **Approach is:**
    - **Build an engineering model that is as near to the production system as possible**
    - **Test fully in an operational environment**
    - **Demonstrate the productivity**
  - **Other factors considered are:**
    - **Support planning**
    - **Logistics, personnel and testing**
    - **Affordability**

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SCHEDULE (CONT'D)

- **DURING THE PRODUCTION PHASE: (2-4 YEARS BEFORE INITIAL OPERATIONAL CAPABILITY)**
  - Objectives are:
    - Establish a stable, efficient production and support base
    - Achieve an operational capability that meets the requirements
  - Approach is:
    - Maintain tight configuration control
    - Assess system performance
    - Identify and incorporate low risk improvements, as required
  - Other factors considered are:
    - Implement support plan
    - Emplace the logistics, personnel, and training structure

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APPENDIX A

TASK BACKGROUND, OBJECTIVE, AND STATEMENT OF WORK

APPENDIX A
BACKGROUND, OBJECTIVE, AND STATEMENT OF WORK

This IDA Paper was written in response to Task Order T-J1-684 and Amendment No. 3. Those portions of the task order that pertain to the background, objectives, and statement of work, provided therein by the sponsoring office are reprinted here.

2. BACKGROUND:

To assist the DoD in the determination and establishment of a U.S. preferred architecture for the future NATO Air Command and Control System (ACCS), IDA conducted a multi-phase study of options for the future ACCS (1982-1987) under the basic task order. The NATO ACCS Team completed the Master Plan in 1989 which included a generic design and ten regional supplements. During 1987-89, IDA also provided detailed technical reviews and comments for a majority of the Master Plan documents. Based on national acceptance of the Master Plan, an Interim Management Group was formed and proceeded to prepare a contract for the preparation of ACCS system specifications. In parallel, a NATO ACCS Management Organization was formed and the Board of Directors began to prepare for an implementation phase beginning in 1991.

The changing international climate and the receding threat has led to a new assessment of NATO's defense posture and operational requirements. There is general agreement that the changing political situation facing the Alliance, coupled with reduction in military equipment and manpower resulting from the Conventional Forces Europe (CFE) process will entail a reevaluation and possible reconfiguration of the proposed ACCS. Consequently, there is an urgent need to analyze options for implementing an ACCS surveillance and communications program

which is both affordable and operationally appropriate.

3. OBJECTIVE:

The objective of this task is to define and analyze options for the NATO Air Command and Control System (ACCS) in a post-CFE environment to include the effects of SHAPE's new operational requirements as constrained by sharply reduced funding projections.

4. STATEMENT OF WORK:

a. Tasks:

Phase XI of the program in FY 1991 will consist of three tasks. The first task addresses the continuing requirement of the sponsor for technical analyses within the context of his NATO ACCS Management Organization (NACMO) responsibilities as U.S. representative to the ACCS Board of Directors. The second task will assess the impact of SHAPE mobility concepts upon the ACCS architecture. The third task will assess the technological feasibility of the ACCS surveillance concept. Specifically:

Task 1 will: Provide technical analyses as required by the sponsor at NATO or ACCS Board of Directors meetings. Additional technical and analytical inputs (oral and written) will be provided, as required, by the continuing activities of the NACMO. Depending upon the availability of the documentation, this will include a review of ACCS system specification documentation.

Task 2 will: Assess the impact of the SHAPE mobility concept upon the ACCS architecture. Determine the types of transportable communications equipment required and the associated costs of integrating "non-static" ACCS entities with the static backbone communications structure. Assess the application of Modular Control Equipment (MCE) or MCE-like equipment to support ACCS surveillance and control functional requirements as "non-static" entities.

Task 3 will: Assess the technological feasibility of the ACCS surveillance concept and define options. Evaluate the feasibility of implementing the ACCS sensor fusion/recognized air picture concept during the mid to late 1990s. Assess the communications requirements of various surveillance options and provide an operational tradeoff which will include mobility considerations.

b. Additional Guidance:

Should specific geographical data be required for the analysis, it will be selected from the Southern Region of NATO.

APPENDIX B

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